BOSTON UNIVERSITY

College of Business Administration

THESIS

Material Management at the Ideal Shipbuilding Company

by

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CHAPTER I

Background

Shipbuilding and shipping played a decisive role in the economic development of the colonial days and continued to exert a powerful influence on the economic development of this country until the time of the Civil War. During this period the population was centered about eastern seaports; the movement of commodities between these centers was easily accomplished by some form of water transportation. It was relatively simple to obtain inexpensive material for shipbuilding because there were vast expanses of virgin forests close to the seacoast. The culmination of this period came during the middle of the nineteenth century, with the American Clipper ships showing our flag in most of the ports of the world. The size of the American Merchant Marine at this time was second only to the Merchant Marine of England.

While the American shipbuilding and shipping industries reached their peak just before the Civil War, new inventions were being perfected by the European countries which completely changed the shipbuilding techniques. Metal steamships replaced wooden vessels, and shipbuilding and shipping became large-scale enterprises, requiring heavy investments and scientific management. Shipbuilding became localized near sources of steel products, and shipping became localized at ports having deep harbors. It became a recognized fact that shipbuilding and shipping were essential to the welfare and security of the State.

The transition from wooden vessels to iron vessels, and later to steel vessels, changed the nature of shipbuilding from a craft industry in which each piece was separately fitted, to an assembly opera-

tion in which pieces were cut and punched according to patterns and placed in the hull according to schedule. The transition from the sidewheeler to the screw propeller, which had been perfected in England prior to the Civil War, took place at this time. Another improvement was the introduction of the compound steam engine which made for greater operating efficiency.

The first important impetus to the builders of iron ships came from the Navy Department when as a wartime measure, contrary to peacetime practice, it ordered three iron-clad ships, the most famous being the Monitor.

The economic position of the builders of iron ships remained extremely weak for more than two decades after the end of the Civil War. The gradual change from wood to iron as a material for large ocean-going, steam vessels was practically completed during this period. The changeover from wood to iron as the basic material for shipbuilding did not help the industry, but rather hindered it in two respects - by increasing the cost of material and the cost of labor. The iron industry at this time was being protected by a high tariff. Therefore material costs increased rather than decreased. The primary source of iron shipyard workers was from the iron industry, where the wage rate was higher than the prevailing shipyard wage rate. Therefore, this higher wage rate had to be equalled by the shipbuilding industry.

About 1880 steel was introduced into shipbuilding on an economical basis as the result of technological improvements in the processing. This material could be shaped cold by powerful machines which reduced its cost. About this time the Navy Department reversed its policy regarding the construction of naval vessels at naval shipyards only. In

1883 Congress authorized the first four steel warships to be constructed at private yards. These ships were the Chicago, Boston, Atlanta, and the Dolphin. (1) As the result of this change in policy, the Navy became an important customer of the shipbuilders, thereby greatly improving the status of the industry. As the result of this impetus, shipbuilding increased in size and efficiency.

Shipbuilding during this period became extremely complex, both technically and economically, and came to stand at the top of a pyramid composed of heavy industries. The heavy industries produced essential raw materials and finished components for the shipbuilding industry, and utilization of the products required technical training of a higher order than had been required in iron ship construction. Therefore, shipbuilding tended to be localized in relationship to two factors, heavy industry and technical talent. Because of the large investments required for a shipbuilding company, it was necessary to secure internal economies, which required scientific management.

Although the change in policy by the Navy had a desirable effect on the shipbuilding industry in this country, it was not of sufficient magnitude to insure continued prosperity. The effect of the new Navy policy was to assure the industry of a backlog of orders for continuing business, but neglected to provide for augmenting commercial vessels, either on subsidy or on an outright basis, so as to enable them to operate economically. During the latter part of the nineteenth century there was growing recognition of this fact. Congress endeavored

(1) U.S.Stat. 477, Mar. 3, 1883.

to aid the industry by adding shipbuilding materials to the free lists, but this did not prove effective. To aid the shipping interests, an Act was passed by Congress in 1891 providing for mail contracts, payments to be based on the speed of the vessel. This Act likewise proved ineffective for halting the decline of our foreign trade. With the outbreak of World War I, the foreign flag tonnage which had been serving our foreign commerce was withdrawn. To correct this situation, Congress in September of 1916 passed the Shipping Act which authorized the acquisition of vessels by purchase, lease, charter or building. Under this law, the United States embarked on a building program of 2300 vessels. Unfortunately, only a few of the vessels constructed saw wartime service.

After World War I, the American shipbuilding industry went into another marked decline. In contrast to this, the European, especially Great Britain's and Germany's, shipbuilding industries were flourishing during the same period. This fact was called to the attention of the American public by a series of articles and oratory on the subject of shipping and shipbuilding. The theme of these articles and oratory was the foreign domination of our shipping, and the suggestion of a larger American merchant marine as the corrective solution. Sound conclusions could not be drawn from these discussions because they were biased, from selfish interests, or were just the expression of nationalistic and patriotic feelings.

Shipbuilding, as the result of World War II, duplicated the expansion that took place as the result of World War I. The Interval between the wars was a period of gradual decline as far as commercial construction was concerned. President Roosevelt in 1933 aided the ship-

building industry by increasing the amount of naval construction. This was fortunate for this country and the shipbuilding industry, because when the demand for commercial vessels did arise, the industry was in a position to expand rapidly and provide the necessary vessels. The shipbuilding industry has since returned to its prewar size, but its capacity has been expanded, and therefore its operating expenses, particularly overhead expenses, have increased, thereby presenting many new managerial problems.

CHAPTER II

The Problem

This thesis will present a coordinated material control system, called material management, a system geared to reduce to a minimum the number of manhours of non-productive employment and the costs of operation. To handle such a problem as this, there are two possibilities: one, to present an actual case study; and the other, to present a synthesis of several of the best systems, blending the most practicable features of each, and modifying where necessary with additional refinements. The second course is the one I have chosen for my thesis, using the Ideal Shipbuilding Company, a fictional organization, to illustrate the most nearly perfect material control system in a shipbuilding yard. The purpose of writing this thesis is to give additional information relative to the underlying principles of material control. A strict material control system must precede production control in order to synchronize material management with production control at the highest efficiency and on as low a cost base as possible. The actual operation of such a system will be portrayed in the pages of this thesis. The scene will be laid at the Ideal Shipbuilding Company, address unknown. This thesis will give a clear understanding of how material management can supplement production control to bring about the utmost coordination and cooperation between the two and thus bring more and better results without increasing the amount of money or effort expended.

An effective production control system has three major elements: (1) material, (2) manpower, and (3) machine capacity. Having

IDEAL SHIPBUILDING COMPANY

Bill of Material

Issued By.....Made By.....Date.....Approved.....

Item No.	Remarks or Detail Plan No.	Mark No.	Quantity	Material	Description	Pattern or Die No.	Requisition No.	Routing	Sub-Group Analysis
1									
2									
3									
4									
28									
29									
30									

B/M No._____ _____Sheets Sheet No._____

Job No._____

Plan No._____

Title_____

Scheduled Completion Date

Dept.	Sch.Date	Remarks

the required materials, manpower and machine capacity in the correct proportions, the finished product can be scheduled in the desired quantities for delivery at the time it is required. Knowing what constitutes an effective control system is the theoretical side of the problem, but putting it into effect is another problem.

A production control system first comes into play with the receipt of an order from a customer, or the sales department forecast for the next period. After an order is received, it should be broken down through the Bill of Material so that the material requirements can be accurately determined. These requirements are then modified to suit existing conditions of material on hand. The second step is to issue shop orders, which will, through their several parts bring the raw materials, the necessary tools and instructions, as well as manpower, to the work center. If a series of operations are required, a detailed shop routing is necessary so that all operations will be performed prior to its being sent to thefinished goods storage. The final step is the sending of the diary of the trip through the plant to the cost department for cost calculation.

This problem is graphically illustrated by Chart I - "Production Control System."

From the above brief explanation of production control, it is apparent that material control is one of the three major components, with the Bill of Material as its keystone. The function of material control in a continuous process industry resolves itself about the amount of production required. This is not true for shipbuilding, because the amount of production is very limited, usually not more than one or two

Production Control System

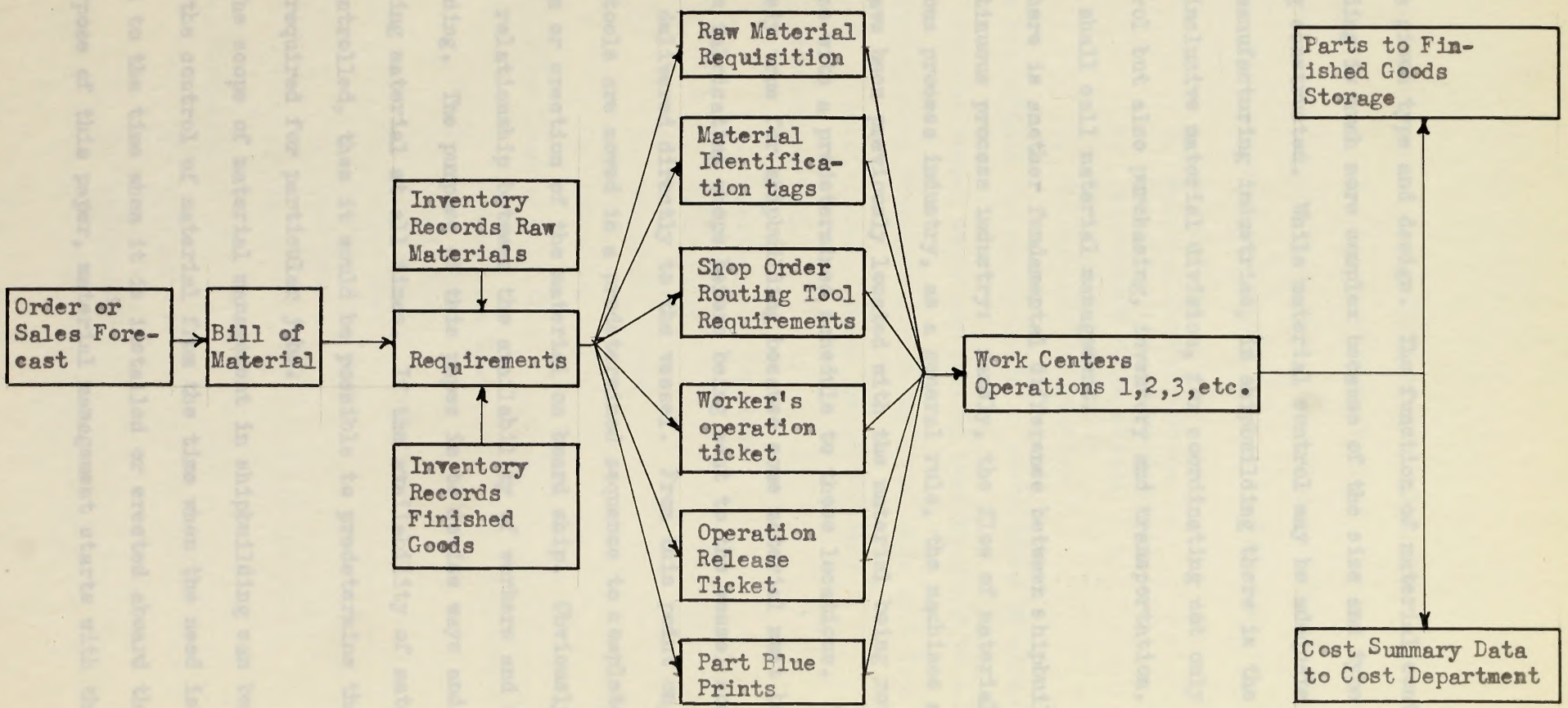


CHART I

Order or Sales Forecast
Edit of Material
Inventory Records Raw Materials
Inventory Records Finished Goods
Requirements
New Material Identification
Material Identification Tape
Shop Order Routing Tool Requirements
Machine operation ticket
Operation Release Ticket
Part Plus Points
Work Centers Operations 1,2,3,etc.
Parts to Finished Goods Storage
Cost Summary Data to Cost Department

CHART I

vessels of a given type and design. The function of material control in shipbuilding is much more complex because of the size and type of the vessel being constructed. While material control may be adequate for continuous manufacturing industries, in shipbuilding there is the need for an all-inclusive material division, for coordinating not only material control but also purchasing, inventory and transportation. This division we shall call material management.

There is another fundamental difference between shipbuilding and the continuous process industry: namely, the flow of material. In the continuous process industry, as a general rule, the machines and operators have been previously located with the material being routed in accordance with a predetermined schedule to those locations. This is not completely true for shipbuilding because some material must be routed first to the fabricating shops before being sent to the vessel and other material is delivered directly to the vessel. From this point on, workers with their tools are moved in a predetermined sequence to complete the installation or erection of the material on board ship. Obviously there is a direct relationship between the availability of workers and materials in shipbuilding. The purpose of this paper is to devise ways and means of controlling material at all times. If the availability of material could be controlled, then it would be possible to predetermine the number of workers required for particular jobs.

The scope of material management in shipbuilding can best be defined as the control of material from the time when the need is first established to the time when it is installed or erected aboard the vessel. For the purpose of this paper, material management starts with the com-

pletion of the development of the first working plan, but prior to its submittal for approval and subsequent distribution. Knowing the starting point and the ending, something must be controlled to achieve the desired results. The functions that are controlled are as follows:

1. Scheduling
2. Material Control System
3. Manufacturing and yard orders
4. Procurement of materials
5. Material distribution
6. Salvage and Reclamation

To consolidate the requirements of every piece of material that enters into the vessel under one general heading would be a herculean job. Shipbuilding practices divide the total area into four main divisions, with 29 subdivisions. These are as follows:

A. Structural Hull

1. Castings and forgings
2. Templates
3. Fabrication
4. Erect and fit
5. Ream-Bolt, Rivet
6. Test
7. Launching

B. Miscellaneous Hull Work

1. Hatches and Door
2. Hull piping
3. Ventilation
4. Auxiliary Hull Machinery
5. Joiner Work
6. Caulked Wood Decks
7. Boat Gear
8. Mast-Boom - etc.
9. Paint

C. Machinery

1. Boilers
2. Engines
3. Auxiliaries

4. Shafts - Propellers
5. Main Condenser
6. Engine Piping
7. Stacks and Uptakes
8. Floors and Grating
9. Miscellaneous Tools and Fittings
10. Tanks (Portable)

D. Electrical

1. Main Propulsion
2. Light and Power
3. Intercommunication (1)

For the purpose of contrast, a direct comparison with the automobile industry, whose production methods are wellknown, should be made. Standard production in the automobile industry basically amounts to having available each working day at a predetermined rate so many frames, wheels, fenders, engines, and bodies, to be supplied to the main production assembly belt. This idea of an assembly belt is also true for subassemblies, such as motors, where engine blocks, crankshafts, connecting rods, pistons, with piston rings, crankcases, valves and valve springs, and cylinder heads, are fed at a predetermined rate to equal the production of the main assembly belt. This is what has become to be known as mass production, which is based on an arbitrary number of automobiles to be manufactured per day. With standard products such as automobiles, it is possible to refine the production control system with time studies because conditions are relatively standard. To further facilitate the production sequence, special attention is paid to the design of the product as well as to tools and jigs. With only one variable, the number of cars to be produced per day, it is also possible to work out

(1) Phillip S. Renaldo and Herbert F. Fitton, "Material Control in the Shipbuilding Industry," Harvard Business Review, Oct. 1929, Vol. VIII, No. 1

material procurement and delivery schedules so as to make the entire procedure practically automatic.

The major variable, the number of major units that will be produced per interval of time, is determined by sales research in the consumer market. Once the numberof units to be manufactured has been established per element of time, it is relatively a simple matter for the production analyst to determine the number of sub-assemblies and components that will be required for that period. Knowing the goal, in such an industry, it is possible to spend both time and money to refine such a system so that it will operate on a practically automatic basis. Coordination is the keystone of the continuous process manufacturing industries. Under such circumstances nothing is left to chance. Raw material and sub-component requirements are carefully analyzed and material contracts are drawn up so as to provide for a continuous flow of material for all operations. Once the enterprise starts to roll, everything has been provided for, and their integration provides the final product at a predetermined rate. Integrated production is only half the story, the other half is that it must be produced at a competitive cost. Likewise, every cost angle has been thoroughly investigated, again leaving nothing to chance.

Shipbuilding in this country followed the European shipbuilding methods until 1900. About that time, American industry was breaking away from the traditional European methods of doing things, and started to develop new methods, which have led to mass production in some industries.

The development of the mold loft system, where structural plans of the vessels are expanded to full size for the purpose of making ac-

curate templates, was one of the revolutionary shipbuilding developments made by this country in shipbuilding. By making templates of each plate, channel, angle and beam, it was possible to save time, labor and effort by knowing beforehand that a certain so-fabricated piece of material would be suitable when installed or erected aboard ship. Being able to standardize the steel requirements, it was also possible to improve the operating efficiency of the steel mill and to further coordinate steel fabrication. When the standardization of individual steel sheets, shapes, and sub-assemblies, fabricated on the basis of the mold loft layouts, proved to be successful, bulkheads, and deck houses were also prefabricated. Techniques developed during World War II carried prefabrication to a point where whole sections of the vessel are preassembled, welded and dropped nearly into place on the erection cradles.

The commercial shipbuilding industry has, in the immediate past, produced a custom-built product, sometimes only one, other times two, and seldom more than four vessels of a design. Where elaborate studies into the refinement of particular systems in mass production industries are financially advantageous, they are not in shipbuilding. Consequently other methods, not as expensive, must be instigated to provide for every piece of material whether it be the main propulsion machinery or the smallest valve. Material must be provided at such a time so that it can be fitted into the vessel's construction sequence most economically both from the standpoint of department cost and cost of the vessel as a whole.

From the foregoing, it is obvious that mass production methods

are not suitable for shipbuilding, where there are only several similar vessels to be constructed. However, there are certain elements and techniques of mass production that can be advantageously adopted and modified so as to be beneficial for shipbuilding. Material management in shipbuilding is an adaptation of some of the material control techniques of mass production industries.

The problems of material management first arise during the initial discussion between the prospective buyer and the shipbuilders on the proposed design requirements which specify certain materials that must be used. The design requirements are based on what the prospective buyer desires in relation to the type of cargo, docking and unloading facilities, return cargo, speed and capacity. These requirements also have financial considerations such as existing freight and passenger rates, operating costs, and expected return on investment. After due consideration, the type, design and general characteristics of the vessel are determined on these considerations. The buyer engages a marine architect to represent him in his dealings with the shipbuilder who is selected through competitive bidding. Arrangements are then made to sign a contract for the construction of a vessel in accordance with specifications furnished with the bid, as well as financial arrangements to cover the method of payment. Thus a new ship is to be constructed by the Ideal Shipbuilding Company, the successful bidder.

The function of the architect is to enterpret the buyer's intentions and desires as detailed in the contract and supplementing specifications. Usually there is an artist's conception as to what the vessel will be like when finished that has to be interpreted into prac-

tical designs. In the development of the practical plans, material requirements are specified that have to be passed upon by the architect. Likewise, other general and specific requirements are developed to the contract plan stage, such as type and rated horsepower of propulsion equipment, tank spaces for fuel and water, type of cargo holds, whether refirgerated or not, crew's living spaces, passengers' living quarters and public spaces. Added to this are such additional equipment as navigational equipment, radio equipment, intercommunicating equipment and various safety appliances.

Material management has three critical dates about which its work revolves: (1) keel laying, (2) launching, and (3) contract delivery. The availability of material, or the lack of it, has a definite bearing as to whether the critical dates will or will not be met. Let us assume that the purchaser has specified in the contract that delivery will be made within twenty months. The availability of certain steel plates and shapes, plus fabricating time, determine the keel-laying date. Likewise, the launching date is determined by the availability of other material, and the progress of construction. If a large component, such as a turbo-generator for the vessel, is not immediately available, the launching date can be governed by its availability. In the final stages of construction, shortages of material and equipment, for numerous reasons, become in many instances the controlling factor for determining the actual delivery date of the completed vessel.

Knowing that material has an important part in the determination of the critical dates of shipbuilding, what procedures can be de-

vised to control the flow of material so as to eliminate all possible material bottlenecks? Shipbuilding being a custom industry, it is not possible to have the refined production control methods of the continuous-process industries. But it is possible to use some of their methods, modified to suit shipbuilding, with good results. Mass production uses the technique of sub-assemblies to augment the main production belt. Likewise, it is possible to use sub-assemblies in shipbuilding to improve production sequences. The problem in shipbuilding is how to determine sub-assemblies for production purposes. The Ideal Shipbuilding Company solves this problem by dividing up the entire vessel into "Groups" for construction purposes. "Grouping" can be defined as the arbitrary allocation of certain sections, compartments, or areas of the vessel into individual entities for the purpose of construction and outfitting. Inasmuch as these groupings are general, further subdivisions are necessary and are known as sub-groupings. See Chart II. The vessel to be constructed has now been divided and sub-divided so as to limit each individual job to a reasonable working size and controllable time period so that the coordinated effort will meet the three critical dates of keel, launching and delivery. The numerical grouping sequence automatically designates which work is to be accomplished first, and the group numbers are from one to ten. By adopting such a breakdown of work required to be accomplished, an orderly sequence can be established for the various drafting sections, which in turn furnish specific information to the Material Management Division (Chart III) for procurement of the required material.

GROUPING AND SUB GROUPING

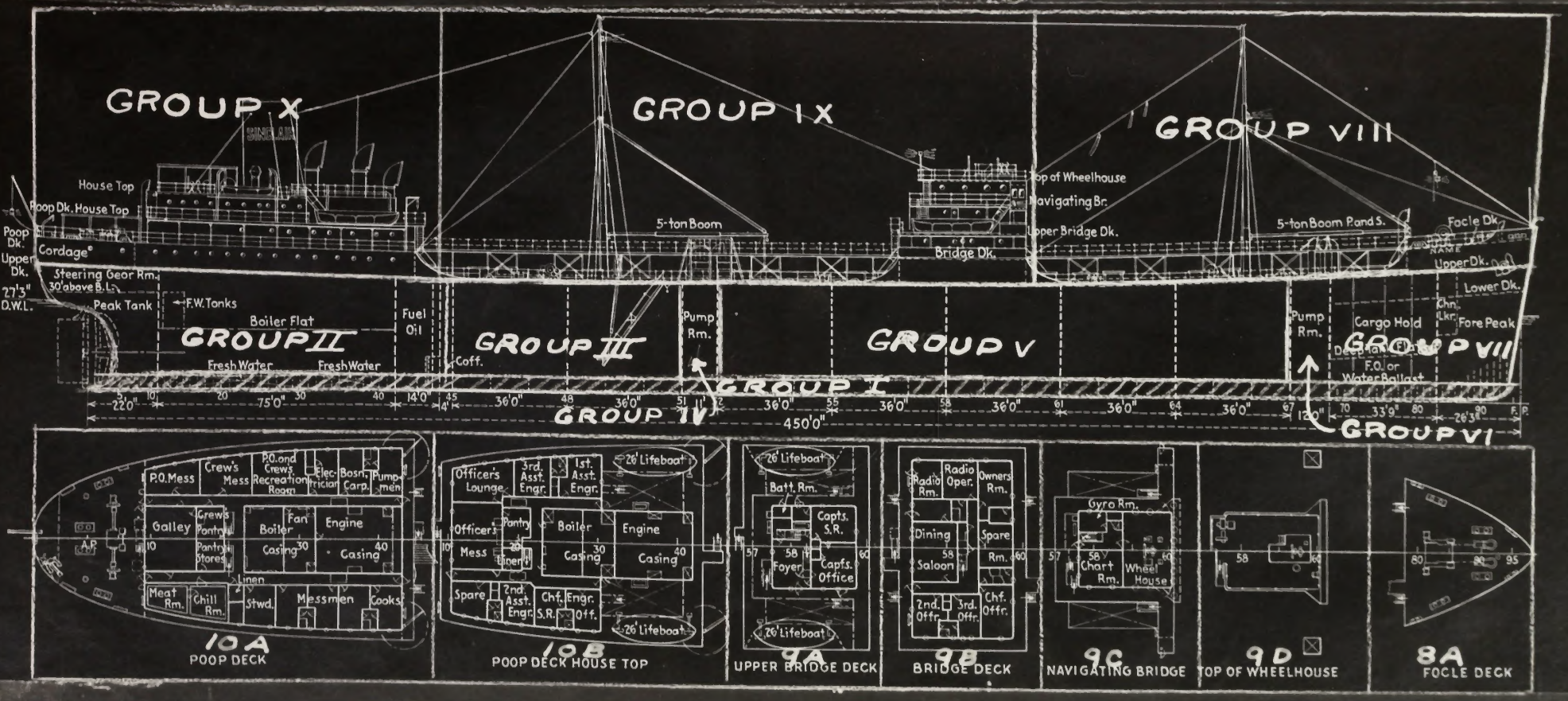


CHART II

MATERIAL PROCUREMENT PROCEDURE

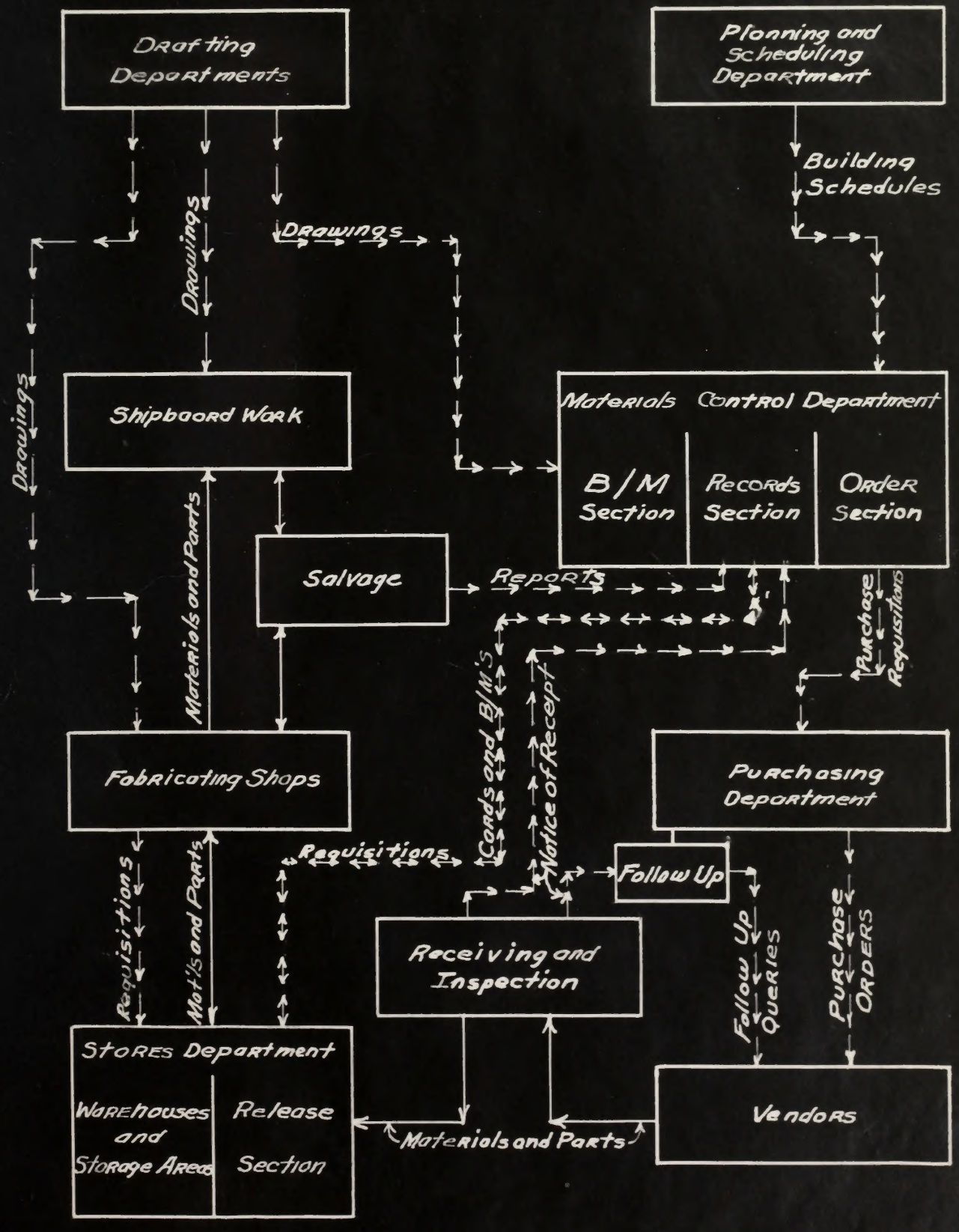


CHART III

CHAPTER III

Drafting Division

As previously pointed out Material Management has three critical dates - keel laying, launching and delivery - about which its work revolves. Inasmuch as the whole procedure of shipbuilding must be viewed to understand a particular phase, it is advisable to briefly review various interrelated functions directly affected by material management. After the vessel has reached the design phase, the general characteristics are well enough known for the Planning and Scheduling Department of the yard to tentatively assign various completion dates for various portions of the vessel. These tentative dates include the allotted time for design, drafting, building and outfitting to meet the specified contract delivery date. Having tentatively accepted the allotted time schedule, the next step is the "grouping and sub-grouping," which will be explained in detail later, of the vessel into entities, such as living spaces, cargo spaces and machinery spaces. This tentative work schedule is then the subject of a series of conferences with the yard manager and superintendents, for purposes of establishing definite keel, launching and delivery dates. Once these dates have been fixed, then the construction sequence is determined.

In Chart II, on the previous page, the construction sequence is as follows: the keel is Group 1; machinery spaces, Group 2; tank spaces, Groups 3 and 5; and the Pump Rooms, Groups 4 and 6. The problem is what shall be done first, second, third and fourth. Naturally the keel is first. The second job would be the machinery spaces, because the allignment of this equipment has a direct bearing on the work in the aft section as well as on

the launching. The next important work is the boring and the fitting of bearings in the stern tubes, which is slow, tedious work and is assigned to be accomplished next. By the process of elimination, the forward spaces are completed last in this sequence. However, this sequence is not always true, because the delivery of important equipment such as the turrets on a large naval vessel may be the controlling factor about which all other work is scheduled. Therefore, there is no hard and fast construction sequence, it all depends upon the facts of the case.

In the meantime, the various drafting departments have received sufficient design dates to prepare plan lists in detail, showing each structural, electrical, engineering and outfitting plan that will be required to complete the vessel in accordance with contract specifications. These plan lists are again the subject of a series of conferences with the yard manager and the superintendents. Having previously decided the keel, launching and delivery dates as well as the construction sequence, the problem now is to group the plans on the plan list so that their release will conform with the previously agreed upon critical dates. Once the plan grouping has been completed, dates are established for plan issue, material ordering and receipt, structural work, electrical work, engineering work and outfitting work. Confirmation of the agreements reached at these conferences should be prepared and issued to all interested personnel in the form of group charts and schedules. Within the framework of these groupings and time limitations, section leaders, regardless of whether they are assigned to the shops or the drafting departments, organize their work. Disagreements are bound to arise, but these are resolved by the Planning and Scheduling Department. Compromises are

usually worked out between the affected parties on all unsatisfactory schedule requirements. Upon final approval by all interested parties, dated plan schedules should be officially issued to all operating departments for departmental planning purposes.

From the above brief description of the initial planning functions of getting ready to build a vessel within a specific time period, it is obvious that the availability of the correct type, quantity and size of material is essential. Limiting the discussion now to the Draft-Department, certain working plans must be fully developed, and approved and released to the Material Management Division prior to a certain date. When these plans are received by the Material Control Department they are to be routed to the corresponding Bill of Material Sections, that is Electrical plan to Electrical Bill of Material Section, for the purpose of preparing bills of material as well as ordering the material listed thereon. Prior to the official release of the Bill of Material, and the release of the requisition to Purchasing, the Bills of Material are sent to the Planning and Scheduling Department for delivery dates and departmental routing for yard manufactured material. These dates and departmental routings are recorded on the bill of material and on the requisition for purchasing. To complete one cycle of the bill of material, let us follow a requisition through the purchasing procedures. Under normal circumstances, the Purchasing Department Buyer would send out requests for quotations for the material detailed on a particular requisition, indicating that the required delivery date is that which has been furnished by the Planning and Scheduling Department. The award of the formal purchase order is based on three factors: suitability of material offered,

price and delivery date. It is common knowledge that price is not everything. A low price for the desired material with a late delivery date is not satisfactory. A higher price for the specified material, but with a good delivery date, however, would be acceptable. It sometimes happens that late promise deliveries are received from all solicited suppliers. In this case the problem is referred to the Planning and Scheduling Department for either rescheduling or decision that the yard will manufacture the required unit instead of having to purchase it. There is one other phase of purchasing and that is expediting, which will be discussed later. Suffice it to say at this point that two independent follow-up procedures are used, one by Planning and Scheduling, and the other by Purchasing, for various purposes. In the case of special equipment, plan approval is required prior to starting manufacturing the unit. The responsibility of following plan development and plan approval rests with Planning and Scheduling. These plans are also required for contract plan development, such as foundations. This phase is closely followed for potential delays which may result in further compromises regarding plan development and scheduling shipboard installation to meet the new material delivery dates.

Returning to the Bill of Material, its official release to the yard should be considered either a yard manufacturing order, or a requisition. Every piece of material required to do a particular job is detailed on it, with an indication of the source of supply. Taking as an example, the simplest purpose, that of assembling the required material to complete a sub-group for installation aboard ship, all of this material has to be assembled in one place by the warehouse, boxed and

stored until required for installation. The other purpose is for yard manufacture by one or more yard shops prior to being sent to the warehouse for temporary storage. In the latter case the Bill of Material is considered as a shop work order, which must be completed on or before the date indicated. There is a double responsibility under this procedure: first, to manufacture to meet the scheduled date; and second, not to manufacture so far in advance as to cause congestion in the warehouses or aboard ship.

The procedure used in controlling the flow of material through the yard shops must be coordinated with the material requirements aboard ship. The practical way of handling this material and work in process is by periodic meetings between all concerned. The various problems of each department are discussed and remedial action is taken to avert major delays. The usual cause of these complaints is the lack of material resulting from poor deliveries from various sources directly affecting the basic progress. Corrective action should be instigated by management where departmental agreements cannot be reached resulting from manpower shortages, departmental shortages or material shortages.

CHAPTER IV

Materials Control Department

The function of the Materials Control Department is to establish the basic inventory records for material management at the Ideal Shipbuilding Company. By adopting the material management system which is based on plan requirements, as shown on the Bill of Material, in principle, it is possible to point out that actual material requirements are known in advance of any requisitioning. From this principle, it is also possible to state, in theory, that the stocks of material on hand are temporary and are only needed to guard against shortages resulting from poor material deliveries. Continuing this idea further, it is also possible to state that all material including reserve stocks will be consumed by the time the contract is completed. This is the ideal picture of material management, but it is also known that the actual consumption of some items of material is greatly at variance with the planned requirements. With the introduction of the tabulated Bill of Material on all working plans, and with ordering being accomplished from certain key plans, with necessary cross references, it is possible to strive for the Utopian goal of ordering and having available only the actual material requirements.

The Ideal material management system has as its foundation a symbol number for each item of direct job material that differs in commodity, type, size, or in any other respect from any other material requirement. In cases where there are extensive quantities of non-standard or special commodities being used, such as doors, hatches, manholes, metal furniture and ventilation fans, the basic symbol number is assigned, but

a supplementary record has to be prepared showing their exact location for installation.

The original symbol list is prepared in advance on a general commodity basis with block reservations of numbers for future additions of material coming within the general commodity heading. These reserved numbers are utilized whenever a new commodity is required that has not been previously symbolized. After a certain number of new symbol numbers have been assigned, the symbol lists are reissued for the Bill of Material Section records and utilization. It is the rule of the Ideal Shipbuilding Company that letter suffixes to previously assigned symbol numbers will not be tolerated to indicate any difference in the commodity, as the practice greatly increases the possibility of error.

After the symbol list has been prepared, approved and issued to all interested parties, including the Record Section of the Material Control Division, the next step is the preparation of the Inventory Cards for the Records and Release Sections of the Material Control Division. Inventory Cards are prepared in duplicate, either when an estimated requirement is ordered in advance or when a plan requirement is received from the Drafting Division. The Inventory Card has spaces provided for the following information:

1. Symbol number
2. Description
3. Contract number
4. Plan number
5. Purchase requisition number
6. Quantity
7. Balance

This procedure is followed whenever a new material requirement becomes known whether it be estimated or actual, after a symbol number

has been assigned to it. The Order Section copy of the Inventory Card is filed by commodity, type and size, while the Inventory Card of the Release Section of the Stores Department is filed by symbol number. These two records are henceforth kept separately by these two activities with the reproducible bill of material being the connecting link. The procedure that the Release Section follows upon the receipt of the Bill of Material is described in Chapter VI.

When a plan has been completed by the Drafting Division, it is turned over to the corresponding Bill of Material Section of the Material Control Division. For example, if the Electrical Drafting Section finishes a plan it is released to the Electrical Bill of Material Section. The same procedure is followed for the Engineering and Hull Sections. Examination of a released plan will show that the quantity, type and description of material has been detailed and the symbol number has been omitted.

The first step that the Bill of Material Section takes is to locate the inventory card corresponding to material description on the plan. From the Inventory Card, the symbol number is determined and is filled in on the plan Bill of Material. The Inventory Card will also indicate the source of material, whether it be yard manufactured or purchased. If there are twenty items of material or only one on the released plan, the Inventory Card for each item is located and the corresponding symbol number is recorded on the plan. The second step is the preparation of a reproducible copy of the Bill of Material shown on the plan including the symbol number. If the material is yard-manufactured, there is a column on the reproducible Bill of Material for the pattern

or die number if required, another column for routing its manufacture through the various yard shops, and its position in relation to the sub-grouping setup as furnished by Planning and Scheduling. If the material is not yard manufactured, then it is requisitioned for outside purchase, and its number recorded in the appropriate column.

The reproducible Bill of Material with the Inventory Card is then turned over to the Order Section. The following information is then posted on the Inventory Card by the Order Section:

1. Contract and job number
2. Plan number
3. Purchase requisition number
4. Quantity required
5. Previously ordered balance not yet assigned

Under this system it is possible to have one or many entries on an Inventory Card, because of the original breakdown of the vessel into groups and sub-groupings. Therefore a running record is maintained of that type of material whether it be for one vessel or a group of different vessels. Where items of material are available in stock either from past contract or advance estimates, the requisition number is not recorded in the appropriate column but the word stock is substituted. If there happens to be a balance still not assigned after the last obligation, the unassigned balance is so indicated in the appropriate column.

The third step is the release of the requisition by the Order Section to the Purchasing Section with the following information:

1. The assigned symbol number
2. The desired quantity
3. The applicable plan number
4. The contract number and job number
5. Previous sources of supply
6. The required delivery date

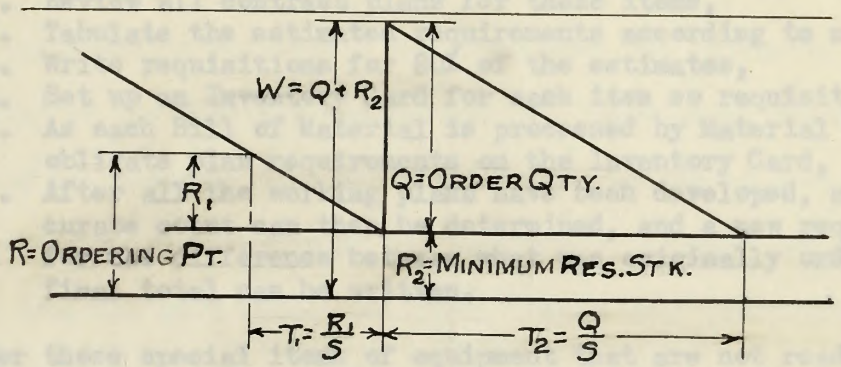
When these various steps have been accomplished, the reproducible Bill of Material is released to the blueprint room for reproduction and distribution to the departments concerned.

By establishing the above detailed procedures, it is possible to keep the basic objective of material management in the forefront, which is placing requisitions to purchase materials that are needed without accumulating excessive quantities. However, it must be recognized that there are three distinct problems here: first, that of procuring materials common to shipbuilding; second, that of procuring common materials in general supply; and third, procuring special materials. Recognizing these three distinct material categories in shipbuilding, provision must be made for procuring material in each group. For items of material common to shipbuilding, the best procedure would be to maintain a minimum balance and reorder in advantageous amounts according to the anticipated yard activity.

The policy of the Ideal Shipbuilding Company regarding common items is to establish maximum and minimum balances for each item. The requisitions for ordering this material are initiated by the Stores Department but validated by the Order Section. The difference between the two limits is a unit quantity that can be readily purchased without paying a premium. One method of accomplishing this is illustrated by the chart and equation found on the following page.

The policy of the Ideal Shipbuilding Company for the purchase of commercially standard material is to issue requisitions for only that which is necessary, plus an allowable waste, if any, resulting from fabrication. To illustrate, the following technique can be used with suc-

Relationship in Stock Variation



Q quantity purchased to give minimum total cost per unit

R minimum point in stock level when order is placed

R_1 theoretical minimum stock necessary if orders always come in on time and production always withdrew the same number per day. Theoretically the old stock, R, will be gone just as the new stock arrives.

R_2 reserve stock necessary because theoretical minimum, R, cannot always be depended upon. Reserve will depend on time for procurement and the nature of the material and not on the size of Q

S estimated rate of consumption in pieces per year

T_1 procurement time in years, from requisition to delivery of goods into the storehouse. Does not usually vary greatly with the order. Can be considered a constant for any one material

T_2 time in years to consume the stock Q

F ratio of actual to theoretical minimum

$$R_1 = T_1S$$

$$R = FR_1 \quad FT_1S$$

$$R_2 = FT_1S - T_1S \quad T_1S(F-1)$$

CHART IV

Relationship in Stock Variation

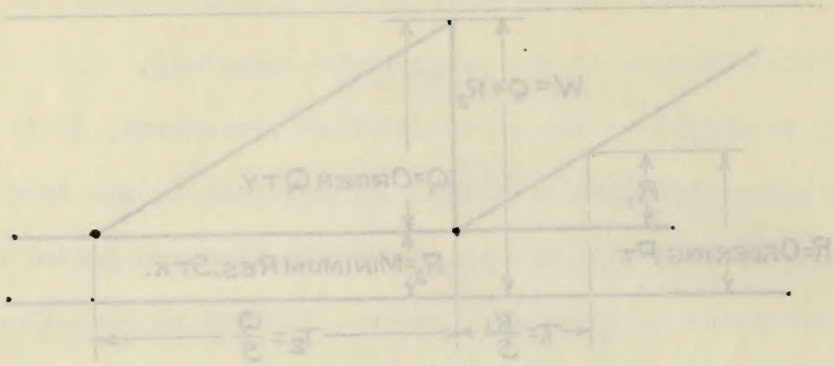


CHART IV

cess by the Order Section:

1. Review all contract plans for these items,
2. Tabulate the estimated requirements according to material,
3. Write requisitions for 80% of the estimates,
4. Set up an Inventory Card for each item so requisitioned,
5. As each Bill of Material is processed by Material Control, obligate plan requirements on the Inventory Card,
6. After all the working plans have been developed, an accurate count can then be determined, and a new requisition for the difference between what was originally ordered and final total can be written.

For those special items of equipment that are not readily available in commercial channels the Ideal Shipbuilding Company has to make a decision between two alternatives: (1) to manufacture; or (2) to buy. If the decision is to manufacture, then the problem is to obtain the required materials for yard manufacturing, which would be handled under the usual procedures. However, if the opposite decision is made, to purchase, the problem is one for the purchasing section to locate a manufacturer who can fabricate the desired equipment within the various limiting factors, and in accordance with the governing specifications.

Having established procedures for procuring specific quantities of materials for particular purposes, it is only logical at this time to briefly outline the disbursement of this material either to the fabricating shops or to the vessel for installation. Whatever department requires an item or a group of items of material for a particular job makes out a yard requisition, describing the desired material by symbol number, description, contract number, quantity and required date. This request is then presented to the Release Section for approval. The proper inventory card is located by symbol number in the Release Section's files, the description is checked, along with the contract number, plan number, quantity

and required date. Assuming that all of this information is correct, the disbursement side of the Inventory Card is filled in with the requisition number and the quantity released. The final step for releasing material is the posting of the manifest numbers and the location of the material to be used on the requisition. It is standard practice to assign the balance on hand on the first manifest not completely released and then proceed to disburse from the next oldest manifest. Under this procedure, there will be established that inventory utilization system known as first-in first-out, which is of some benefit to the accounting department for cost determination. Another advantage to using first-in first-out material is that material in stock will be more current than under the system of last-in first-out. If there is a possibility of deterioration or obsolescence, the first-in first-out system has some advantages over the last-in first-out.

After the submitted requisition has been validated by the Release Section, it is returned to the originator, or sometimes it is sent directly to the warehouse for disbursement of the material detailed thereon. After the material has actually been released, one signed copy of the completed requisition is returned to the Records Section for final posting to the inventory card to show that the material has already left the warehouse, and the duplicate copy of the requisition is retained by the Stores Department for their records.

CHAPTER V

Purchasing Control

The position of purchasing agent within the framework of material management in shipbuilding is somewhat different from the ordinary. Usually the purchasing agent has definite responsibilities with certain duties that are shown on the organization chart. The importance of the purchasing department varies with the degree of standardization. If the product has been standardized to the degree that quantities, type and qualities have been predetermined with corresponding limitations then the position is simplified and subject to general manufacturing control.

In contrast to the purchasing agent whose powers are limited by general manufacturing control, there is another type of purchasing agent whose duties have assumed such importance as to make him vice-president in some industrial organizations. In the latter category, the purchasing agent decides on many questions concerning the purchase of material such as when, where and how much. These purchases, many times, have a direct bearing on the finances of the organization, which could mean the success or failure of a particular enterprise.

Within these two extremes the purchasing under materials management rests at the Ideal Shipbuilding Company. The purchasing department is part of the material management division; consequently, some of the duties normally assigned to purchasing have been reserved for other sections within the material control department. Actually the position has more duties than under the standardized manufacturing setup, but less influence than a vice-president in charge of purchasing. To the aggressive

purchasing agent, this would be a backward step in the evolution of purchasing. However, it must be remembered that purchasing is a functional operation, which can change with changing organizations.

The underlying objective of material management is to control material from the time its need is first apparent to its actual installation aboard ship. Based on this principle, centralization of the purchasing functions is essential for successful material management in a shipbuilding company. By centralization, the responsibility and duties are definitely established for the following functions:

1. Application of scientific methods,
2. Coordination of material purchases with production requirements,
3. Establishment of uniform buying policies,
4. Promotion of greater competition among suppliers, resulting in better prices and deliveries.

In shipbuilding the coordination of material purchases with production requirements is accomplished by the grouping and sub-grouping of certain areas for the sole purpose of having many small jobs, the control of which can be readily maintained. It is true that this type of work segregation makes more work for the purchasing department, but when viewed from an overall position there are definite advantages. Two advantages are: (1) the cost of accumulating material of similar characteristics by placing one purchase order would be more than would be more than would be saved; and (2) the working capital of a company is not tied up for purchases for extended periods of time.

Using the quotation, "No man's judgment is better than his information," as the basic purchasing principle, it is therefore necessary to build up a library of information for greater effectiveness. For maxi-

mum operating efficiency the purchasing department should either be furnished or have specific information readily available on the following subjects:

1. Accurate specifications and descriptions of what is needed,
2. Name of department which will use the product ordered,
3. The required delivery date based on building schedules,
4. A list of acceptable and reliable vendors who can supply the material,
5. Production cost of any item to the vendor so that the buyer will know values,
6. Amount of a fair spread between the vendor's cost and selling price which will provide healthy competitive atmosphere,
7. A complete record of past transactions. (1)

The requisition issued by the Order Section of the Material Control Department furnished to the Purchasing Agent has the quantity, description, and applicable specifications, as well as the interested departments, the required delivery date, and the list of acceptable, reliable and previous suppliers. Regarding the production cost of any item, a library of information is built up first by vendors' catalogues, which are constantly being supplemented by current quotations, cross-indexed according to products and firm name. In addition to this, I believe that it is also essential to have separate sets of files according to commodities purchased and vendors, for future reference. Other handy references are charts and graphs showing the composite trend of prices of raw materials supplemented with individual graphs showing price fluctuations of the individual commodities, such as steel, machine tools, and special trade indices. Conditions are always changing, so that care is necessary to have information that is up to date. Live information may

(1) Koepke, C.A., Plant Production Control, New York, John Wiley & Sons, Inc., 1941, p. 153.

be had, and is considered useful, from trade publications and associations, statistical services, and vendors agents. It must be borne in mind that this type of information is only relative and is classified as a working tool for the purchasing department, that is available for use as needed.

The piece of paper that starts the wheels of machinery moving in the purchasing department is a purchase requisition which serves a dual purpose: first, the purchase requisition is a written statement of the need of certain material; and second, it is a request on the purchasing department to procure the material detailed thereon. Eliminating from the present discussion the requisitions that originate in the Plant Maintenance Department or other service departments, the greatest portion of the requisitions originates in the various order sections for the purchasing department to process. There are three general categories of materials that have to be purchased: yard stock, commercially standard material and special material.

Purchasing material for yard stock can be classified as the procurement of material regularly used for all types of construction whether it be commercial or naval. The underlying principle here is to coordinate the use of this material with current construction so as to obtain the lowest price, but not to purchase in excessive quantities so as to lose all previous gains because of additional storage charges and losses. The frequency with which this type of material appears on the approved plans is fairly constant and in fair size quantities. Therefore, rather than ordering the exact requirements as shown on the approved plan each time, the order section places a requisition for a predetermined unit quantity. The accounting system must be modified so as to have stock ac-

counts for this type of material.

For accountability of material so used there is a material transfer requisition prepared by the department desiring such material. This transfer requisition is likewise returned to the Records Section of Material Control Department for posting and maintaining records of existing stocks, and as an indication of when to reorder.

The second general category of purchasing material is that of procuring commercially standard items. In the case of steel plates, angles and shapes, prior to the full development of the working plans a reasonable estimate of the tons of this type of steel can be made. Without specific quantities of size or shapes, it is advisable to negotiate a fixed price on a poundage basis. Thus the opportunity is given to the regular suppliers to know approximately how much basic raw material will be required. As the plans are developed the detailed requirements are furnished to the suppliers for certain scheduled delivery dates. Other standard commodities can be first purchased on an estimated basis of the future needs, and when all plans are developed, the unordered items can be purchased separately.

The final category of purchased material is special material, where the purchasing department acts as the middleman between outside vendors and the Design Section. Material of this type is of a new design not previously approved for use on the type of vessel involved. The manufacturer must first prepare plans, material lists and submit both of them for approval by the interested parties. It is advisable in my opinion to have the purchasing department establish and maintain such contacts, by being the liaison between the Design Section and the manufacturer. Once

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the equipment plans have been submitted and approved, it returns to a basis of straight purchasing and expediting, functions that are best handled by the Purchasing Department.

There is one other category in which material ordered from the Bill of Material can be classified, and that is group purchasing of small and miscellaneous items. Bearing in mind that the cost of placing such orders may be much greater than the actual dollar value of the material purchased, a setup should be madeto handle such problems expeditiously. The recommended solution for handling such purchases as quickly and as inexpensively as possible is contract group - purchasing from a reliable jobber. The usual contract is that the material so ordered will be furnished at actual cost to the vendor plus a fixed percentage of the cost to him. Under these circumstances the vendor's cost records must be available to the purchaser on inquiry.

The function of the purchasing agent within the framework of materials management is somewhat limited in many respects. The material to be ordered is specified as well as the quantity, and applicable specifications. The function performed by him is procurement of the specified quantities, quality, with delivery being promised within the specified time, and at the most advantageous price for the organization. When a purchase order is actually written, it should be in a multiple copy form, such as hectographed, for distribution not only to the vendor, but also to the departments concerned within the company's organization, such as the order section, the records section, the stores department and interested yard departments. This purchase order should duplicateall of the information originally furnished to purchasing department, plus accounting

information and the supplier's name. It is not advisable to have the prices being paid for material on certain copies distributed to the various departments for information. Provisions can be made to eliminate such information at the hectographing machine, by using an altered purchase order form. The reason for the distributing of the purchase order information is discussed elsewhere.

CHAPTER VI

Inventory Control

Having established procedures for determining the exact amount of material required, and the purchasing of the same, the next phase of material management is inventory control. Inventory, in its broadest sense, can be defined as an itemized list of goods with their estimate worth. However, in an industrial sense and as used in this thesis, manufacturing inventory includes all material for shop work, and installation material required for the completion of the vessel and its control from the time it arrives at the plant until it is finally released for installation aboard ship. The ramifications of a good inventory control system are numerous: it speeds up production by having material available when needed; it reduces the required storage space by better control of the storing of material; it reduces the risks of depreciation and obsolescence, to say nothing of damage to material while it is being stored; and finally, it reduces the amount of funds tied up in material and work in process inventory.

Westinghouse Electric and Manufacturing Company in its 53rd Annual Report, 1938, revealed some interesting figures relating to better inventory control in terms of inventory turnover. Over a nine-year period, from 1930 to 1938, the average inventory turnover for all products was 2.6 times per year. The highest rate of turnover during this period was 3.7 for 1930 and the lowest was 1.85 for 1933. The term inventory is rather all inclusive in this case, and for the purpose of illustration, let us convert it back to a more common basis - money. The

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Westinghouse Electric and Manufacturing Company in its 52nd Annual Report, 1928, revealed some interesting figures relating to better inventory control in terms of inventory turnover. Over a nine-year period, from 1920 to 1928, the average inventory turnover for all products was 2.6 times per year. The highest rate of turnover during this period was 3.7 for 1920 and the lowest was 1.85 for 1923. The term inventory is rather all inclusive in this case, and for the purpose of illustration, let us convert it back to a more common basis - money. The

amount of money involved does not have to be known, but the value of it does, and let us assume its current value was 5%. If the inventory of company A only turned over once a year the actual cost of the money invested in that inventory per year would be 5% of the original cost, making its basic cost to the company 105% of the price paid. Company B, on the other hand, turns over its inventory three times a year and all other conditions are the same. The relative cost of the inventory of Company A to Bompany B would be the 105% to 101.7%, for basic cost purposes. (1) Cost reductions of this nature are necessary to maintain a fair return on invested capital. Interest is not the only cost for carrying inventory. There are others, such as, increased overhead expenses resulting from insurance, taxes and depreciation on the additional facilities as well as depreciation and possibly obsolescence of the inventories themselves.

The two ovjectives of inventory control may be stated as follows:

(1) To keep the total dollar investment in inventories as low as possible,
(2) To maintain a proper balance between supply and demand for material in the shipyard.

Both of these objectives are approachable through material management in conjunction with grouping and sub-grouping of material requirements in accordance with the Planning and Scheduling Department's accepted schedule. By grouping and sub-grouping certain areas of the vessel in accordance with prior agreements covering the construction sequence, only the desired material is being processed and being procured at any one time. The basis of construction is augmented with detailed

(1) 5% divided by 3 plus 100% = 101.7%

schedules for every piece of material that enters into the ship so as to finally assure that the various groups of material will arrive at the building ways or outfitting docks in proper sequence and without any pieces being missing. The success of such an undertaking is dependent to a large degree upon the proper group segregation and future labor operations. There are two general categories of material under this ideal grouping system: First, material required for erection ; and second, the material required for completion of a particular compartment. There is little or no difference between these two general categories in the initial stages of planning and scheduling, the preparation of the necessary drawings, the ordering and purchasing of material fabrication if necessary, and their delivery to the place of temporary storage. The Bill of Material is the keystone for both groupings. It is essential that erection material be completely available prior to the starting of any work, while in the case of material for completing compartments, the effect of shortages is not as great, but should not be allowed. Proper grouping of material which is reflected in the Bills of Material is essential for success. The Bill of Material in this case for inventory purposes becomes a check-off list. There is recorded on the Bill of Material information as to whether material is yard-manufactured or purchased. Using the symbol number beside the various items of material, it is possible to quickly determine from the corresponding inventory cards the availability of the required material. If all is on hand, it can be immediately released on request. If not, the necessary steps can be taken, as will be discussed later, to have the material expedited. The basis of this theory of procedure is that, in my estimation, it is

easier to expedite material required due to shortage reflected in the inventory control procedures because of the longer time element, than it is to expedite material required immediately for construction purposes.

The function of inventory control in the Stores Department is theoretically to know at all times the status of all material. The basis of the Ideal system is to have the order Section prepare duplicate inventory cards either when estimated requirement is to be ordered or when a plan requirement is received from the Drafting Department. One of these cards is retained by the Order Section and the second one is sent to the Stores Department. In contrast to the Order Section, which files its cards according to commodity, the Stores Department files its cards according to symbol numbers. In order that both of these cards be maintained in unison, in general, increased emphasis must be put on the respective functions performed by these cards at both record centers by exchanging pertinent information.

The duplicate inventory card set-up satisfied the major demands of the Material Control Division and the Production Division. One of the basic fundamentals of coordinated planning is the assurance that material will be available on the scheduled required dates appearing on the Bills of Material. Just how is this accomplished?

Reviewing briefly the Ideal of material management for clarity, the first step was the addition of the Bill of Material to working plans, so that the symbol number, the quantity required per plan, description and specifications would be detailed in one place on the plan. After the plan has been accepted and approved, or if the time element is criti-

cal, before acceptance and approval, a reproducible copy of the Bill of Material is prepared and subsequently distributed. All available information is detailed on the Bill of Material showing where the material will be furnished from: stock, yard manufactured or purchased. The Stores Department records the obligated store material on the various Inventory Cards. Upon receipt of either purchased or yard--manufactured material, these Inventory Cards are posted, and a duplicate copy of the warehouse receipt is furnished to the Records Section of the Material Control Department. After this information has been posted to the Inventory Cards, the same information is posted on the Bill of Material. In the case of shortages on certain Bills of Material at the critical dates, it is an easy matter to refer back to the Inventory Cards for similar material according to symbol number. In the event that the required material is available, but for another job, it is only a bookkeeping transfer to release the material for the current work group. To have this material management system operate smoothly, it is necessary to have certain forms for certain purposes that will give the desired information. No definite set of forms or records can be established to suit all shipyards, because of different operating and accounting systems, but there can be a general classification, as follows:

Principal forms

1. Receiving report of purchase material and equipment
2. Delivered to stock for manufactured materials record
3. Balance of classified stores record
4. Balance of unclassified stores record
5. Stores requisition
6. Credit requisition
7. Purchase requisition
8. Production order requisition
9. Bin Tag

Less important forms

1. Notice of material not on hand
2. Inventory verification slip
3. Notice of danger point
4. Request for count of stock
5. Order of stock material (1)

The classification of material has been discussed, the forms used to control material have been outlined, but how do all of these things tie in together to form a control system? For the purpose of illustration, the procedures at the Ideal Shipbuilding Company for the control of material in the Stores Department are as follows:

The basic records in the Stores Department are (1) Inventory Cards filed according to symbol numbers in some form, visible indexing system, preferably, and (2) the Bill of Materials filed according to predetermined grouping. With the formal release of the Bill of Material, information is furnished to the Stores Department for the first posting on the Inventory Cards, such as:

1. Contract number
2. Plan number and group number
3. Origin of material
4. Required quantity
5. Required delivery date(s)

Each item of material on the Bill of Material is identified by a symbol number which is the tie-in for the Stores Department. Before any posting is accomplished, the description of the material on the Bill of Material is checked against the description on the Inventory Card for possible error. This is to prevent the possibility of errors in posting

(1) Alford, L.P., Principles of Industrial Management for Engineers, New York, Ronald Press Co., 1940, p. 239

Item Inventory Form

1. Notice of material not on hand
2. Inventory verification slip
3. Notice of danger point
4. Request for count of stock
5. Order of stock material (1)

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The basic records in the Stores Department are (1) Inventory Cards filled according to symbol numbers in some form, visible indexing system, preferably, and (2) the Bill of Materials filled according to predetermined groups. With the formal release of the Bill of Material, information is furnished to the Stores Department for the first posting on the Inventory Cards, such as:

1. Contract number
2. Plan number and group number
3. Origin of material
4. Required quantity
5. Required delivery date(s)

Each item of material on the Bill of Material is identified by a symbol number which is the tie-in for the Stores Department. Before any posting is accomplished, the description of the material on the Bill of Material is checked against the description on the Inventory Card for possible error. This is to prevent the possibility of errors in posting

(1) Alford, L.P., Principles of Industrial Management for Industry, New York, Ronald Press Co., 1940, p. 239

which can seriously affect the material control system. It is recommended that the following rule be strictly enforced. No posting will be made by the clerk and no posting will be permitted by the Group Leader unless the symbol number and descriptions correspond from all sources of information. Any errors or discrepancies found are reported to the Group Leader and are referred by him to the Bill of Material Section of the Material Control Department for clarification, before postings are accomplished. Inasmuch as the transfer of information, in many instances, from the Bill of Material to the inventory is a jumping around proposition, each item on the Bill of Material should be checked as posted to the Inventory Card. After all items have been posted to the Inventory Cards, a visual recheck of the Bill of Material should be made to see that all items have been taken care of and then initialled by the clerk doing the posting. To keep all records current, all Bills of Material must be posted daily. This is another cardinal rule of this system.

The second source of information for posting Inventory Cards is the purchase order. Each item of material appearing on the purchase order has a symbol number which is the tie-in with the Inventory Cards of the Stores Department. Again descriptions are checked prior to the posting of the purchase order number on the Inventory Card. If any discrepancies are found they are reported to the Group Leader for clarification with the Order Section of the Material Control Department. It is also necessary to check the required delivery date on the Inventory Card against purchase order required date. This is the second step. Discrepancies are handled as usual. The final step is the placing of the expediting tag over the required month on the top edge of the card for future use.

The third source of information will be the manifest indicating the receipt of material. Each item of material shown on the manifest must be posted to an Inventory Card having the same identical symbol number. Before proceeding with the posting, descriptions of material should be checked, and discrepancies reported. The information to be posted is the manifest number, quantity, and storage location. If sufficient quantity has been received to cover the requirements for present position of the expediting tab, the signal should be moved to the month corresponding to the next requirement not covered by the quantity received. In the event that all of the required material has been received, the expediting tag should be removed.

These Inventory Cards with their expediting tags correctly placed, serve as flags for quickly spotting delinquent material. Inasmuch as the tags only cover months, expediting lists can be prepared using one or more sheets assigned to each of the following months. As the critical dates are approached, purchase orders are received at the Stores Department indicating immediate delivery. In such cases, after the Inventory Card has been posted with the information shown on either the Bill of Material or purchase order, similar information is recorded on the expediting list under the month due. These lists are in the process of preparation for all material due in the next sixty days. Therefore, under such a program occasionally there would be only two expediting lists, but more frequently there would be a third one, if the lists were released on a weekly basis.

When a material group is required to be released there is provision made to check the required material lists thirty days in advance. This is done by taking the symbol number of the required material, locating

the corresponding Inventory Card and recording the information on the Bill of Material from the Card. Should it happen that an item of material is not available, the expediting list should be checked for the latest information.

The final phase of inventory control is the releasing of material being held in the warehouses or outside storage areas. The release of any item of material is instigated by an operating department requisition which must specify either a material grouping or symbol numbers, otherwise there is no tie-in with the inventory records. The release clerk should locate the proper card by symbol number first, and the second operation should be to compare descriptions, after which the unissued balance should be checked to see if there is sufficient balance on hand to satisfy the requirements shown on the requisition. As double check, the contract plan, quantity and required date should be verified to determine that the requisition is valid, and that material is not being drawn unreasonably in advance of the required date. Assuming that the requisition is valid, the Release Clerk should deduct the quantity or quantities being validated from the existing balance and should show a new balance. The next step is posting to the operating department requisition number and quantity on the Inventory Card. The final step should be the recording of packing list numbers and warehouse on the operating department requisition for disbursement purposes. The validated requisition should then be returned to the Operating Department or should be sent directly to the warehouse having the desired material. Upon release of the material, the signed requisition is returned to the Re-Lease Section and a duplicate copy to the Records Section of the Material Control Department.

If for any reason the desired material should not be available, the expediting list should be consulted for delivery information, and it should be so indicated on the Operating Department Requisition.

CHAPTER VII

Traffic

The sequential development of material management now leads to material handling. Previous chapters have dealt with the determination, ordering, purchasing and inventory control of specific material required for the construction and outfitting of a vessel at the Ideal Shipbuilding Company. Therefore, the development of the thesis problem has reached the stage of what to do with the material after receipt but prior to its release to yard operating departments. In a mass production industry, such as the automobile industry, material requirements have been directly geared to the production quotas. In such cases the material received, after verification as to quantity, condition and other purchase order requirements, is immediately disbursed to the temporary storage area adjacent to its entrance on the production. Under such close control, there may be only one or two days' supply on hand. This is not true for the shipbuilding industry as a general rule, where it is common practice to have a floating inventory supply of common items ranging from several days' to several months' supply. Under these circumstances it is necessary to have definite procedures for the receipt, temporary storage and disbursement of material. All of these functions fall within the general category of storekeeping under the supervision of the general storekeeper, who has the responsibility of the physical possession of all shipyard material prior to their release to the various yard operating departments.

The problem of material storage in the shipyard is somewhat different than in the usual industrial plant for two reasons: first,

because the initial release of material does not relieve the Stores Department of final accountability; and, second, because large areas of both inside and outside storage are required at various places in the yard.

One of the large outside storage areas is called the Plate Yard. The work of the Plate Yard is to receive, store, and release plates and shapes to the steel mill. The Hull Order Section originally prepares the steel schedule and at the same time that the Purchasing Department receives a copy, the Plate Yard also receives a copy for their records, thus acquainting this unit with what steel can be expected in the near future. This schedule is prepared and distributed in accordance with the basic grouping scheme and should be filed by job number. At the time that the steel manufacturer makes a shipment of steel, he forwards by mail a copy of the shipping notice direct to the Plate Yard. On receipt of this shipping notice, the Plate Yard should assign storage space for every item detailed theron before the actual receipt of the material, to prevent the last minute search for a storage space. When the shipment of steel does arrive, the checker should have the shipping notice marked up with the various storage locations for the various items, so that he performs two functions at once: checking the material as unloaded; and directing its storage in accordance with previous instructions. For the purpose of being readily able to relocate a given plate, it is recommended that the storage racks be numbered in series by rows, using numbers 100 to 199 for the first row and 200 to 299 for the second row, etc. After the shipment of steel plates and shapes have been stored in the Plate Yard, an office clerk should record the description of each item, such as its size, weight, job number and storage location in the steel schedule as a permanent record.

Because of close working arrangements between the steel manufacturer and the Plate Yard, it is recommended that all expediting of steel plates and shapes be done by the Plate Yard Office directly with the steel manufacturer rather than through the Stores Department.

Nearly all of the steel plates and shapes are worked upon by the Steel Mill prior to actual erection or installation aboard ship. Therefore, another outside storage area is required for such fabricated items as bulkheads, stacks, uptakes and many other sub-assemblies which are not suitable for warehousing because of their size. After the Steel Mill has completed its work on such assemblies, it is recommended that they be manifested to the Stores Department for temporary storage. These fabricated sections are then transferred from the Steel Mill to a predetermined area as close to the building vessel till needed. Their location should be recorded on the applicable Bill of Material and Inventory Card for future release when needed by one of the yard operating departments.

The Stores Department should also have the responsibility of receiving, recording, storing, as well as of disbursing all other material except steel, heavy machinery, and other bulky articles that pass through a central point known as the Receiving Platform. Here the recommended procedure is to have the Receiving Platform check this material when received against the vendor's shipping papers and the making out of a receipt showing where the material is to be stored. Later a permanent receipt should be made out and circulated to the various departments concerned with the reproducible master being retained by the Stores Department as part of their records. Another function of the Receiving Plat-

form should be the preparation of vouchers for the Accounting Department so that they will have a record of all material received, so as to know what vendors' invoices should be paid.

In order to be able to move material from one storage place to another, as well as to be able to deliver material to the building ways or outfitting pier, it is recommended that the yard transportation facilities be placed under the direct control of the Stores Department. Three major subdivisions are required for this purpose: Cranes, Automotive Transportation and Railroad Cars.

The purpose of including this Chapter on Traffic was to emphasize the point that it is one of the functions of material management. Because of the nature of shipbuilding, various types, kinds, and sizes of material must be handled and the one best way to dispose of the material handling problem in a shipyard becomes a matter of conjecture and can best be solved when all the facts are known.

CHAPTER VIII

Salvage and Reclamation

To complete the cycle of material management, it is necessary to give consideration to the material that is purchased but for some reason is not utilized on a plant-wide basis. It is true that materials may be wasted in a number of ways. Extraordinary losses of material are caused by fire, and flood, but loss by theft is something that should not be overlooked. The common source of loss or disappearance of material is either by scrap or by waste. Scrap includes spoiled goods from any source, together with material left over by the production processes, which is not saleable, except at a loss, while waste is the expending of material needlessly. For material in these categories, it is necessary to have definite control to determine and to remove the cause before large losses accrue.

At the Ideal Shipbuilding Company, control over such practices is achieved by instituting scrap reports. The underlying principle behind scrap reports is to transmit information regarding losses to the Order Section of the Materials Control Department, which must make adjustments occassioned by the scrap. There are two general sources for this information: (1) inspection and (2) salvage. If material rejected by inspection cannot be reprocessed by the particular department making it, then a form with all the pertinent information should be made out. Under these circumstances it should not be completely scrapped, but sent to the salvage section.

The function of the salvage section is to reclaim for future

use all material and supplies that it is possible to save. The value to the company of such a section can be accurately determined by keeping a record of the materials and supplies actually salvaged. For example, in a yard department, such as the sheet metal shop, where there is considerable soldering done, rather than just cleaning the floor and throwing the sweepings away, it is possible to reclaim the solder droppings by melting them, after segregation, in a retort and recasting them into bars and then these bars can be used as the original metal. Likewise, it is possible to salvage cutting oils by centrifuge. Salvage is not limited to supplies, but can be successfully pursued in reclaiming tools as files, milling cutters and reamers by special process. Likewise, it is possible to reclaim spoiled material and equipment by some additional work, such as rewinding burnt-out motors. Many times it is possible to save expensive work by special processing, rather than throwing it away or selling it for scrap value.

From the above illustrations it is possible to recognize the opportunities that are present in the study of waste or materials and their reduction. The first step to control this situation is a careful study of all wastes, known and unknown. From this study it is then possible to control certain wastes by closer supervision. Should the study reveal that it is not a controllable waste but a by-product of the manufacturing sequence, then a new field of endeavor may be opened - utilization of the by-product.

Generally speaking, utilization of wastes divides into three categories:

1. Salvage
2. Reclamation
3. By-production manufacturing

The salvaging function can be defined as accumulating waste materials, sorting and classifying same prior to disposing of them at the best price.

After material has been through the process of salvaging, certain material is found recoverable, providing a little work is performed on it. This function is known as reclamation. Actually what happens is that the material selected is restored to a suitable condition and used for the purpose originally intended. Naturally this operation calls for men with wide experience and high mechanical ability.

Chemical processes afford the best example of by-product manufacturing. But by-product manufacturing is not limited to the chemical industry alone; metal stamping and trimmings in the shipyard offer many good examples. The theoretical scrap from one trimming operation many times is utilized for another purpose, such as cable hangers. To define by-product manufacturing, one can say it is the utilization of scrap from one operation for another useful product.

According to one authority, management is responsible for 50% to 80% of waste industry. (1) Management while recognizing this responsibility has not always utilized all the various methods of eliminating waste. Some times the engineering division has been requested to redesign the product, other times by decrees, but the most effective way to control waste would be a synthesis of these two methods in conjunction with a suggestion system from the individual workers.

(1) Koepke,C.A., "Plant Production Control," New York, John Wiley & Sons, Inc., 1941, p.192.

Digressing for a moment, many constructive and beneficial suggestions can be made by the men on the job as to how the work can be improved. There is one report issued by a union and confirmed by the management of a steel company that beneficial employee suggestions at the end of the first year of operation cost the company $6900 for new equipment, but saved $173,100. (1)

Hand in hand with the elimination of waste goes the responsibility of surplus disposal. The function of disposing of surplus inventory should not be confused with the functions of scrap and salvage. Surplus material usually results from design changes or the ordering of excessive material, while scrap and salvage is a by-product of manufacturing.

There are various departments which can handle the disposition of surplus material:

1. Sales Group
2. Purchasing Group
3. Separate section within the materials set-up

There are strong arguments for utilizing the sales department on surplus disposal, first because it would utilize idle sales personnel, and second, because disposal is a selling job.

Likewise, in the purchasing group, known outlets are readily available, but the question of policy of buying from and selling to the same concerns has to be thoroughly investigated. It is a better policy to dispose of the surplus material to other concerns, because it creates good-will and brings larger returns to the company.

(1) Ruttenberg, J.H., "The Fruits of Industrial Peace," Boston, Harvard Business Review, May 1940.

Because disposal of surplus material is an important and difficult task, the logical way of handling it would be by a separate section within the materials set-up. It is of the utmost importance that the disposal unit work closely with the materials group so that surplus material may be utilized to the fullest extent. One can readily understand that if the disposal unit were completely separated from the materials group the responsibility of the efficient handling of material would be under two individuals rather than under one. In the course of time, it would probably develop that they were working at cross purposes: one to utilize material, and the other to dispose of material.

CHAPTER IX

Conclusions

The problem of this thesis was the development of a materials management program at the Ideal Shipbuilding Company to coordinate all phases of material control, such as ordering, purchasing, storing, issuing, handling and transporting material during the manufacturing phases and building period of the vessel. The underlying factor of such a program is to insure the availability of material on the job when men start to work. The final objective is the reduction of manhours and the reduction of operating costs in shipbuilding.

The old system of material control was based upon a requisition made out by the mechanic for a piece of material and signed by his quarterman. This requisition was then presented to the storeroom by the mechanic or his helper, and was filled according to the information detailed thereon. The responsibility for the correct type and size of material was with the mechanic. Therefore, if the wrong material was ordered or issued, it had to be reordered, to say nothing of the material that was lost. Another evident fault of such a system was that material, in excessive amounts, was ordered far in advance of the actual need, ostensibly to save time, but actually often the material became lost or damaged prior to the time when it was to be used.

The material management program endeavors to eliminate poor practices by various techniques. First, all erection and outfitting work on board ship is broken down into individual units of work for the purpose of accumulating material for erection or installation in the most

efficient manner. The required material for such a unit is known as a material group. This simplifies the problem of segregation of the required material at the warehouse, because the bill of material is the controlling factor. When a material group is required, it is requisitioned on operating department orders and signed by authorized departmental individuals. In this way it is possible to have all the material available prior to the assignment of workers.

These are only the warehousing and installation phases. There are other phases, such as the coordination of plan development, inventorying, ordering and purchasing, as well as of salvaging and reclamation.

Each of the above phases have developed along fundamental lines so that they would be flexible enough to be utilized in any type of vessel. It must be remembered that the control of material is not something that is static but something that is dynamic. Material requirements are nearly always in the state of flux because of the nature of them: raw materials and purchased parts are processed to improve their characteristics for future utilization. The utilization of the "grouping and subgrouping" ideas tends to narrow the horizons, so that the whole can be viewed from its many entities. Because of technological developments, what may be the best today may be discarded tomorrow. Working with individual units as entities, it is possible to incorporate current developments without seriously affecting the critical contract dates. Therefore, being mindful of these potential changes, all phases of material management have been considered including procedures for the utilization of salvaged and surplus materials.

Although the bill of material has been used as the foundation for this material management control system, it should be recognized that although a certain portion of material can be determined accurately, there is no firm criterion from which to estimate spoilage allowances. Another limitation to this procedure is the fact that in some instances material cannot be processed by production in accordance with the original information. This is not a fault of material management but something that occurs in most industries. Therefore, it must be recognized and dealt with as an inherent problem. Still another limitation to be recognized and compensated for is the design and material specification changes. Again the control of this problem is outside the material management group, but should not be overlooked.

What procedures can be initiated to overcome these limitations to the Bill of Material? There is only one logical answer - better departmental coordination. Regarding how much extra material should be allowed, that is a matter of policy between the materials management division and the various production departments. To eliminate the problem of procuring specific material for a particular order only to learn that it is not suitable, it is necessary to have the plan approved prior to its release to the material control department. Likewise, the problem of design changes should be mutually agreed upon by engineering, production, and material management as to when, where and how the modification will be effected.

The results of better coordination between interested departments would tend to establish a more reliable working basis than commonly exists in the shipbuilding industries today. The accountability of

all material required for production requirements should be stressed, and any deviation should be thoroughly investigated.

Having considered the limitations of the Bill of Material, it is also advisable to mention the good points. The basic approach is a scientific one rather than just a good guess. The unit requirements are definitely known, and it is a simple matter to add a percentage for spoilage and thus to arrive at a reasonable figure. Codification of material eliminates the possibility of ordering and re-ordering the same item of material because all the records for that particular item have been summarized in one place for immediate reference. Because of the characteristics of material, they lend themselves to general classifications: common items, commercially standard items, and special items. Depending upon their characteristics, procedures can be devised to accomplish the final objective without cumbersome records, and without providing material in excessive quantities.

Material management definitely restricts the freedom of action in the purchasing department in two ways: first, the ability to accept a slightly different material, equally as good, at a reduced price; and second, the ability of purchasing to modify the timing of the actual purchase. In both of these limitations, the organization as a whole benefits because things are definitely organized for a desired result. Someone, believing that he is acting in the best interests of the company, cannot endeavor to save a few dollars on material by means of different specifications or timing, only to impose additional expenses as a result of poor material or delivery.

One of the first criticisms of stores and disbursement pro-

cedures under material management would be that it would create friction and distrust between the material and production divisions. But on the other hand, nobody is actually free from restraining influences. Automobiles are designed to develop the speed in excess of sixty miles an hour, but government has passed laws limiting the speed of automobiles. Likewise, material management is for the good of the company as a whole, rather than for just one division. Therefore, limitations and controls should be expected and respected.

It is only logical that if something is to be controlled, it should be in all phases rather than in just one or two. Therefore, material management, as outlined in this thesis, has endeavored to control all phases of material so that techniques could be established to eliminate the trinity of duplication, waste and overlap that is ever-present in the corridors of business.

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